

# Introduction, Plans and Funding

**Giorgio Apollinari**

**Fermilab Accelerator Advisory Committee**

**May 10<sup>th</sup> – 12<sup>th</sup> , 2006**

# Outline

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- **Charges to the Committee/Review Organization**
- **Introduction**
- **HINS Plans (2006-2009)**
- **Funding**

# Charges to the Committee

## 2. High Intensity Neutrino Source R&D

A possibility that has been discussed extensively for the longer term future neutrino program is the development of a  $>2$  MW neutrino source based on a superconducting  $H^-$  linac. Fermilab's approach has been modified over the last year to align this effort more closely with the laboratory's ILC strategy.

The committee is asked to review and offer comments and recommendations relative to the current plan, strategy, and development status of R&D in support of a High Intensity Neutrino Source.

- Go
- Funding Human Resource for ILC R&D (this talk)
- **Design and Technical Systems: R&D effort, prototypes, etc.**
  - 1 Design talk, 1 Integration talk, 7 Technical talks
  - 30 min to 15 min talks

**CAVEAT: NOT A PROJECT REVIEW**



# Charges to the Committee

## 3. High Intensity Neutrino Source Synergies

Identification of possible synergies, or multiple use applications, of technologies developed within the HINS R&D program could provide a cost effective means of advancing multiple options for Fermilab and/or the Office of Science. The most discussed synergy involves the  $\beta=1$  superconducting linac that serves as the basis of both the ILC and HINS. However, other possibilities, while not developed in detail, may exist.

We would like to engage the committee in discussion on possible strategies to maximize mutual benefit to the HINS and other programs. This discussion will include:

- Possible synergies with the ILC
- Possible utilization of the HINS in support of a muon storage ring
- Possible connections with other Office of Science programs

We are interested in any reaction or advice the committee would provide in these areas.

- **Discussion Forum**

- ILC/HINS Synergies on technical elements or solutions originally designed/developed for HINS
- ILC/HINS Synergies on ILC-Test Facility
- Muon Storage Ring/HINS Synergies
- RIA/HINS Synergy.



# APS Neutrino Study

- **Interdivisional Study**

- APS, DNP, DPF, DAP,...

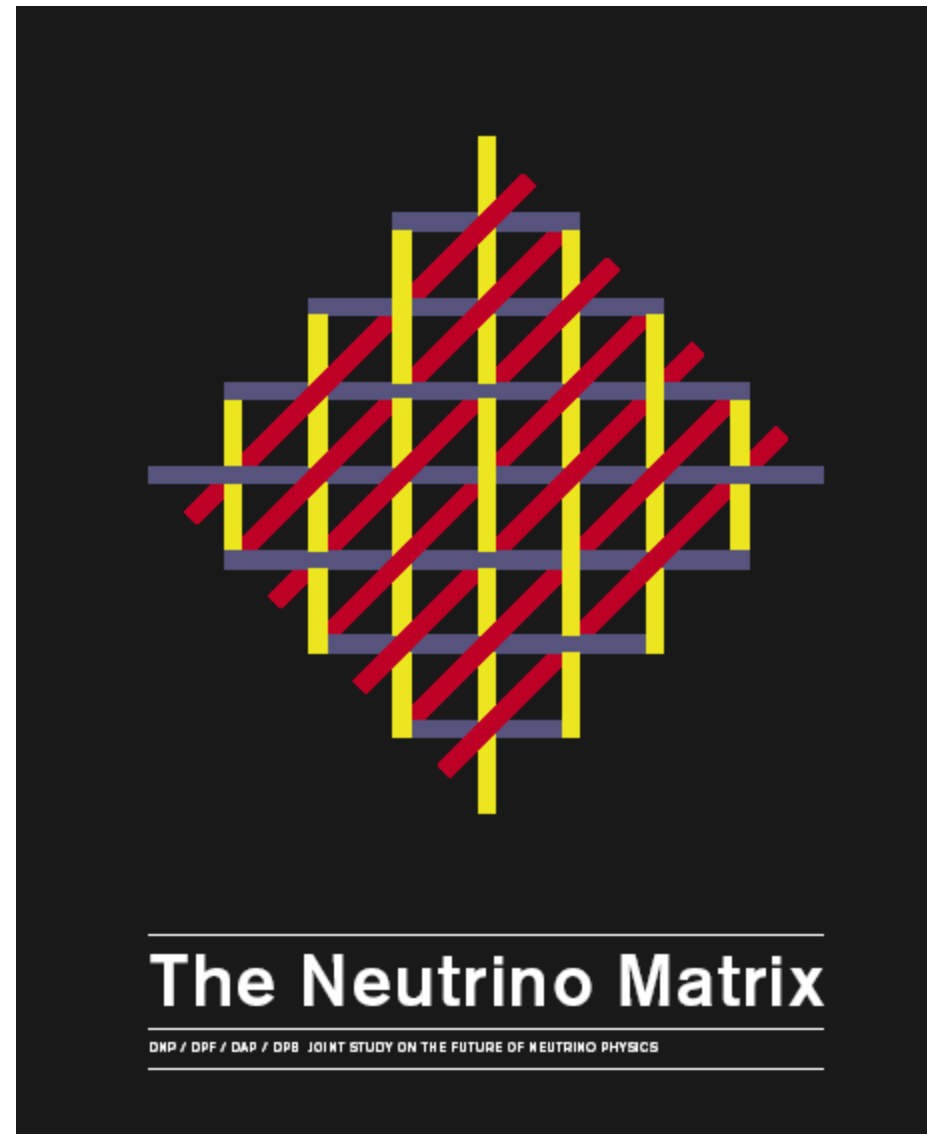
- **Charges**

- Examine broad sweep of  $\nu$  physics

- Create scientific roadmap for  $\nu$

WE RECOMMEND, AS A HIGH PRIORITY, A COMPREHENSIVE U.S. PROGRAM TO COMPLETE OUR UNDERSTANDING OF NEUTRINO MIXING, TO DETERMINE THE CHARACTER OF THE NEUTRINO MASS SPECTRUM, AND TO SEARCH FOR CP VIOLATION AMONG NEUTRINOS. THIS PROGRAM SHOULD HAVE THE FOLLOWING COMPONENTS:

- *An expeditiously deployed multidetector reactor experiment with sensitivity to  $\bar{\nu}_e$  disappearance down to  $\sin^2 2\theta_{13} = 0.01$ , an order of magnitude below present limits.*
- *A timely accelerator experiment with comparable  $\sin^2 2\theta_{13}$  sensitivity and sensitivity to the mass-hierarchy through matter effects.*
- *A proton driver in the megawatt class or above and neutrino superbeam with an appropriate very large detector capable of observing CP violation and measuring the neutrino mass-squared differences and mixing parameters with high precision.*



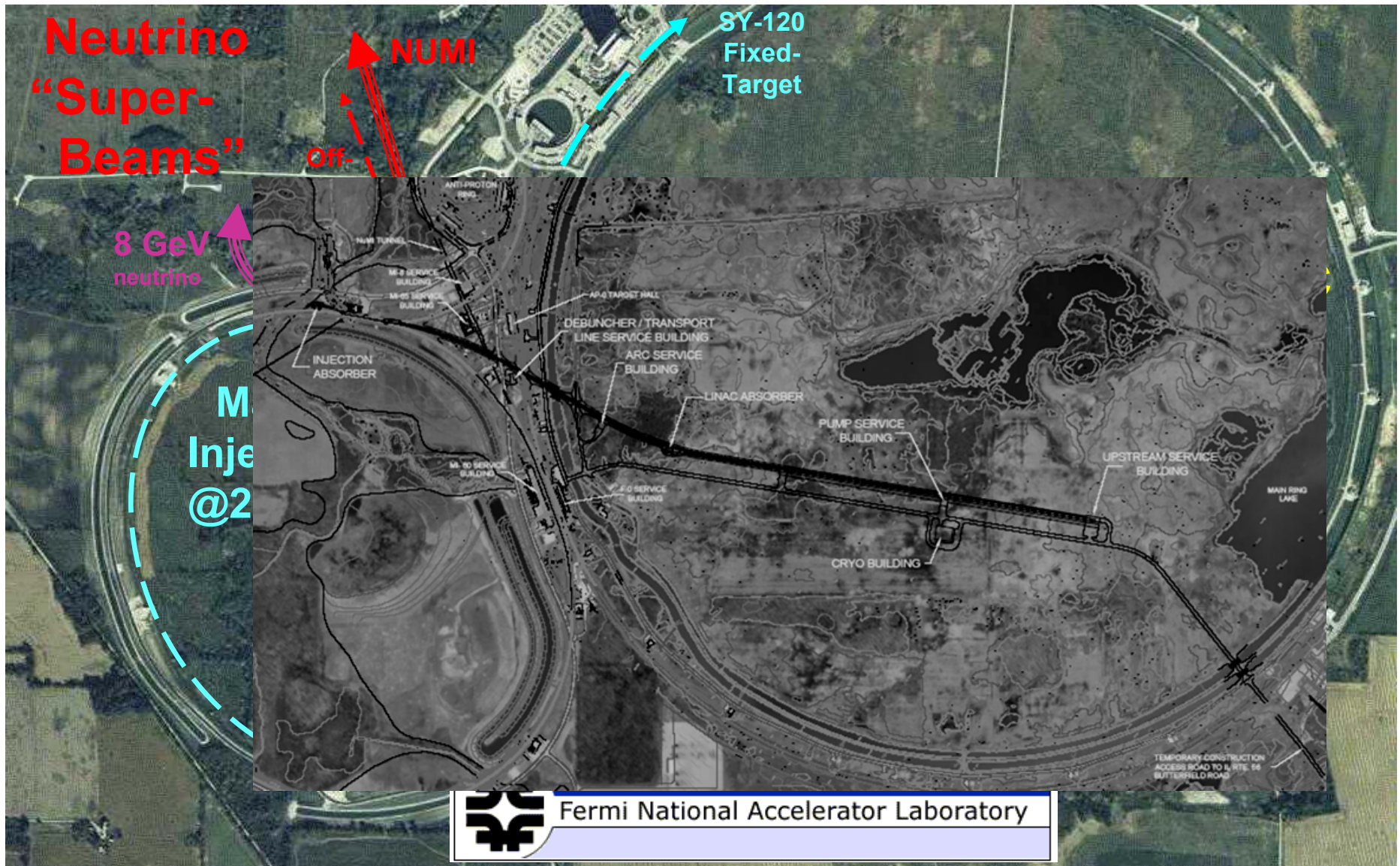
# The Proton Driver

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- **New\* idea incorporating concepts from the ILC, the Spallation Neutron Source, RIA and APT.**
  - Copy SNS, RIA, and JPARC Linac design up to 1.3 GeV
  - Use ILC Cryomodules from 1.3 - 8 GeV
  - H<sup>-</sup> Injection at 8 GeV in Main Injector
- **“Super Beams” in Fermilab Main Injector:**
  - 2 MW Beam power at both 8 GeV and 120 GeV
  - Small emittances ==> Small losses in Main Injector
  - Minimum (1.5 sec) cycle time (or less)
  - MI Beam Power Independent of Beam Energy: *flexible program*

\* *The 8 GeV Linac concept actually originated with Vinod Bharadwaj and Bob Noble in 1994, when it made no sense because the SCRF gradients weren't there. Revived and expanded by G.W.Foster in 2004*

# 8 GeV Superconducting Linac



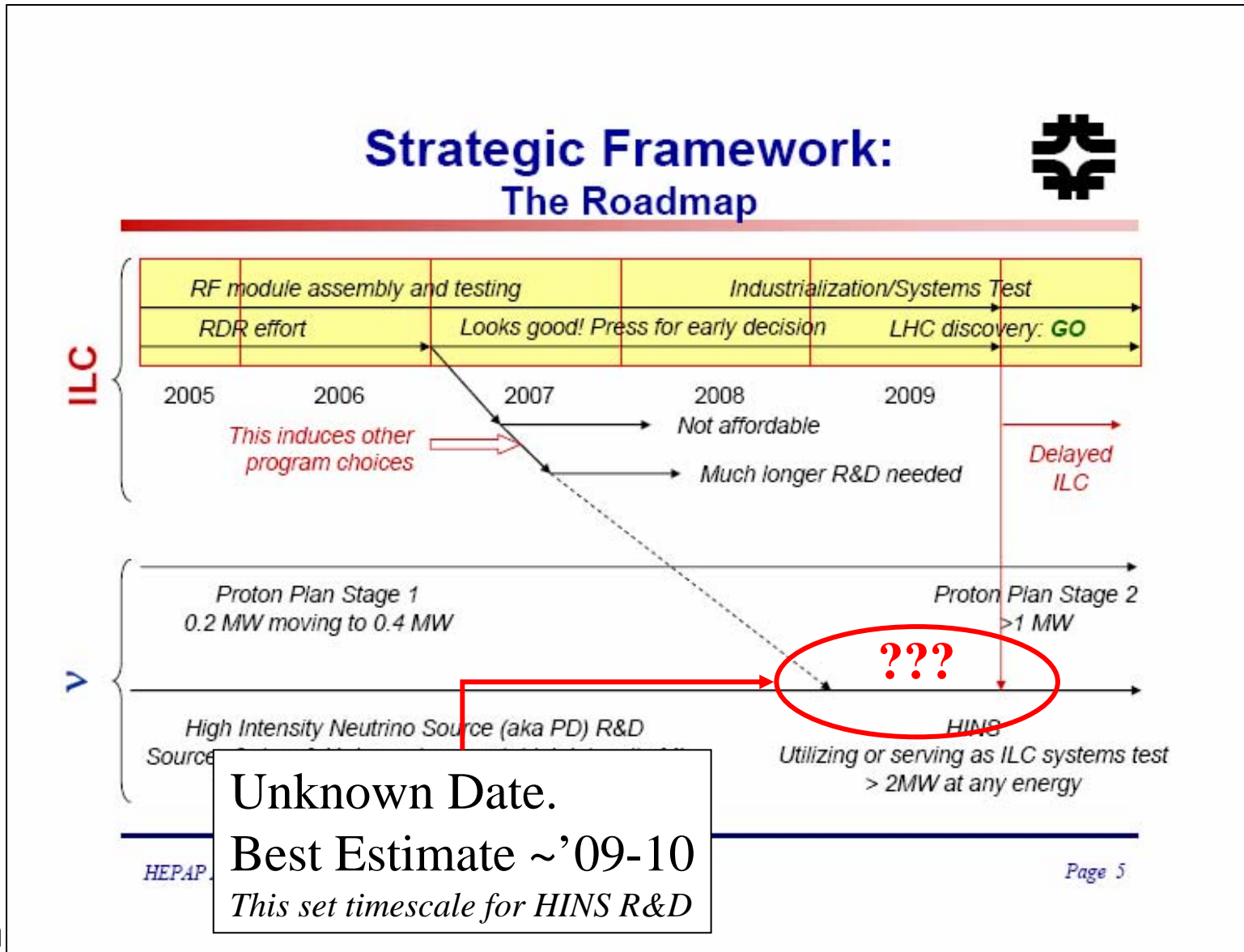
# ILC-PD (HINS) Interplay

## Program Elements and Goals Intermediate Term

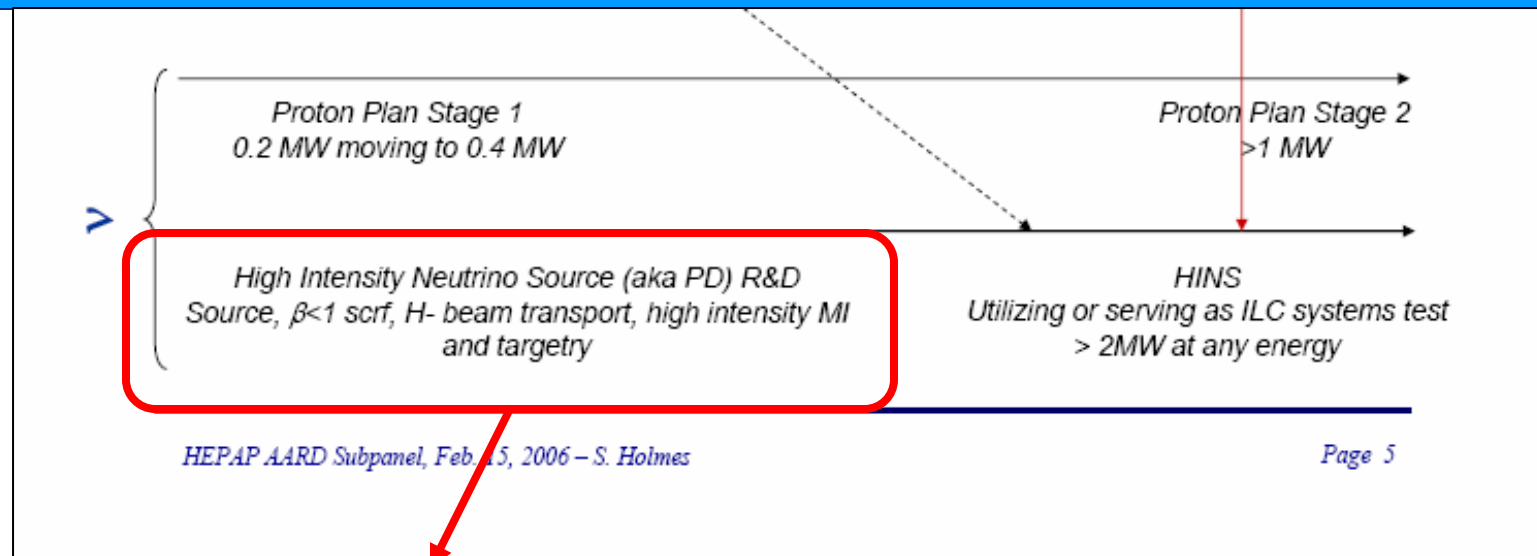


- Goals:
  - Establish Fermilab as preferred host lab for ILC.
    - In collaboration with national and international partners
    - World leader in scrf technologies
  - Work with GDE to define and implement an industrialization plan and the associated major systems test which we believe is required before the start of construction.
  - Develop technologies that could be married to ILC developed cryomodules, to support construction of a high intensity neutrino source if ILC construction is delayed.
  - Assist in the successful commissioning of the LHC and develop a full scale Nb<sub>3</sub>Sn quadrupole for LHC upgrade.
    - Under the aegis of the LHC Accelerator Research Program (LARP)

# ILC-PD (HINS) Interplay (cont.)



# HINS Strategy & Goals (2006-2009)



- **Design fully ILC-Compatible PD**
- **Prove, Develop & Build Front-End in Meson Detector Bldg. (0-90 MeV)**
  - Much of Technical Complexity in Front End Mechanical/RF Systems
    - Test Amplitude/Phase Modulator Technology and RF Power Scheme with H<sup>-</sup>
    - Test RT-SC Transition at 10 MeV
    - Acquire capability to test/operate SC Spoke Cavities at FNAL
    - Send First Beam in the world through Spoke Cavities
    - Test Axis-Symmetric focusing and Beam Chopping
- **Design/Plan MI Injection Line & MI Upgrade**

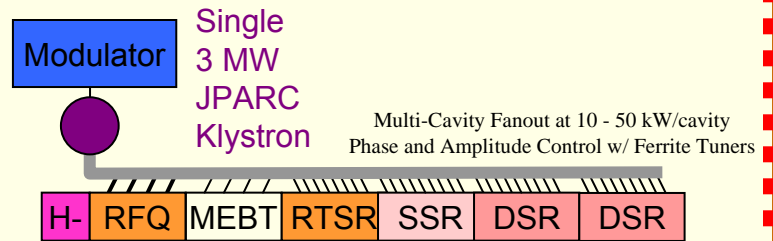
# 0.5 MW Initial 8 GeV Linac

11 Klystrons (2 types)  
449 Cavities  
51 Cryomodules

## "PULSED RIA"

Front End Linac

325 MHz  
0-110 MeV



## $\beta < 1$ ILC LINAC

1300 M

2 Klystrons  
96 Elliptic  
12 Cryom

~80 % of the Engineering &  
Technical System Complexity

Cost

Modulator

Modulator

10 MW  
ILC  
Multi-Beam  
Klystrons



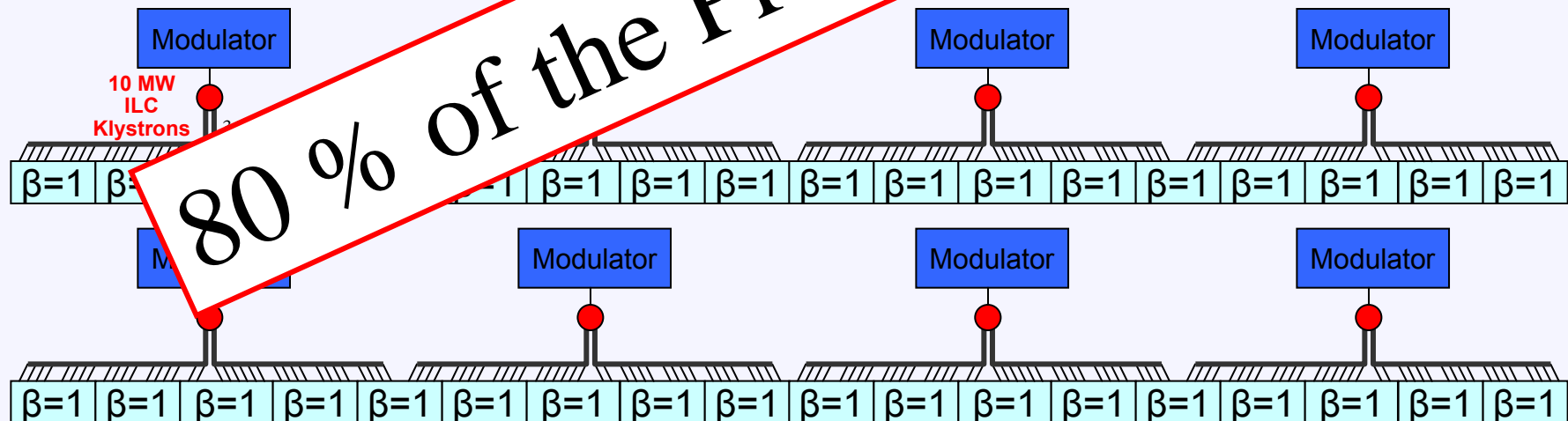
8 Cavities / Cryomodule

## ILC LINAC

12

Klystrons

288 Cavities in 36 Cryomodules



# Agenda

## Wednesday, May 10

### High Intensity Neutrino Source R&D (Organized by Giorgio Apollinari)

1:15-1:35	Introduction, Plans, and Funding	G. Apollinari
1:35-2:05	Beam Dynamics/Linac Simulation	P. Ostrumov
2:05-2:35	Systems Integration and Meson Lab Setup	R. Webber

3:10-3:25	IQM and Phase Shifters	D. Sun
3:25-3:45	Klystron and Modulator	A. Moretti
3:45-4:10	Ion Source and RFQ	D. Moehs
4:10-4:25	Solenoids and Room Temperature Section	T. Page

## Thursday, May 11

### High Intensity Neutrino Source R&D (cont.)

8:30-9:00	Spoke Cavities and Cryostats	T. Nicol
9:00-9:20	Focusing Solenoids	I. Terechkine
9:20-9:35	Main Injector Injection	D. Johnson

### Discussions of HINS Synergies

10:10-11:00	Potential synergies related to the HINS R&D program	
11:00-12:00	Potential synergies related to construction of HINS	
11:00-11:15	Issues related to a dual use (ILC Test and HINS) facility	D. Bogert
11:15-12:00	Discussion	

Design  
Talk

Integration  
Talk

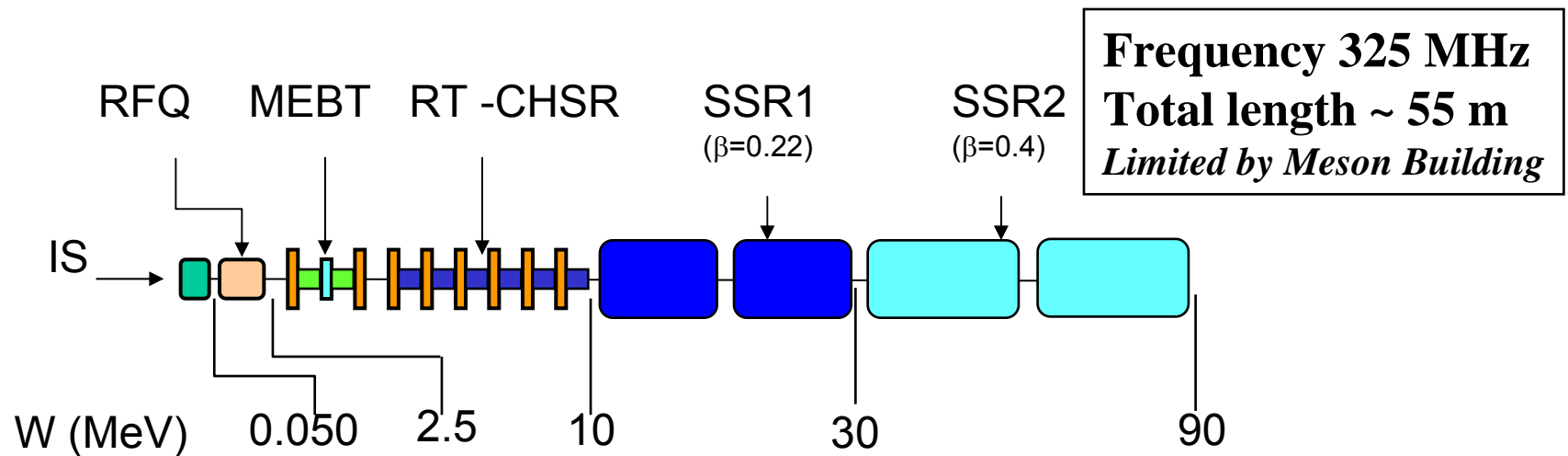
Technical  
Talks

ILC-PD  
Synergies  
Discussion

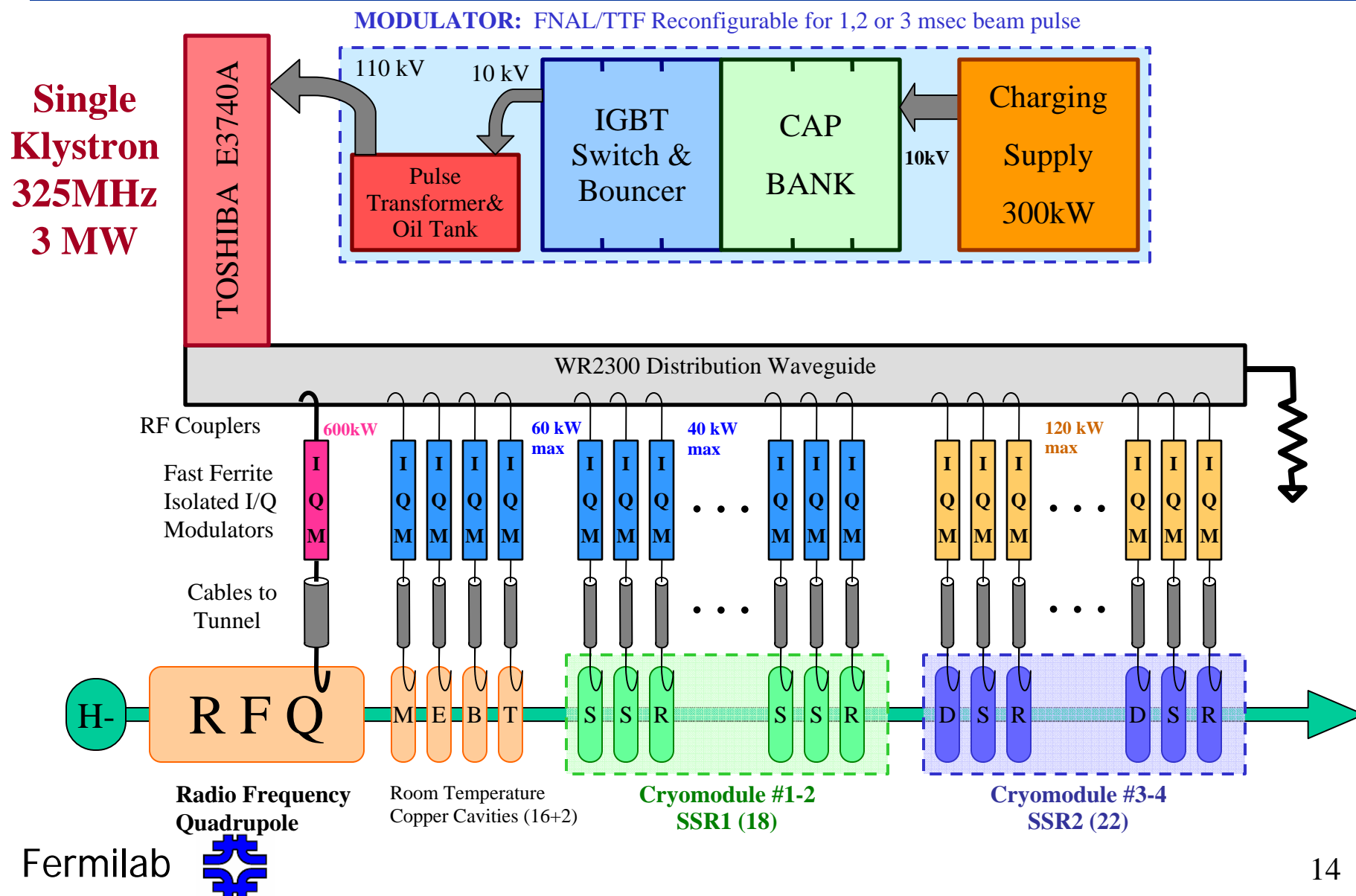


# Front End - Beam Line Layout

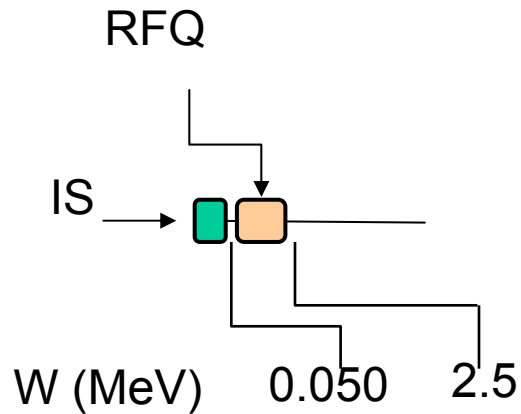
Ion source H <sup>-</sup> , LEBT			50 keV
Radio Frequency Quadrupole		4-5 m,	2.5 MeV
MEBT	(2 bunchers, 3 SC sol., chopper)	4 m	
RT TSR section	(16 resonators, 16 SC solenoid)	10 m	10 MeV
SSR1 section	(18 resonators, 18 SC solenoids)	14 m	30 MeV
SSR2 section	(22 resonators, 12 SC solenoids)	20 m	90 MeV



# Front End – 325 MHz System Layout



# HINS Front End - Stages (1)

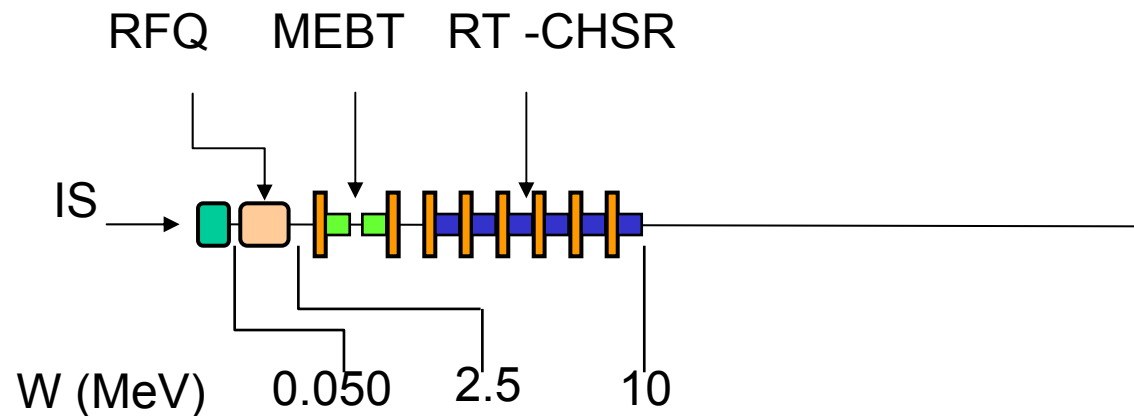


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- **End FY06/Beg FY07**

- Klystron/Modulator/Power Distribution
- RFQ
- Test Cryostat/Prototype SSR
- Klystron & Power Distribution

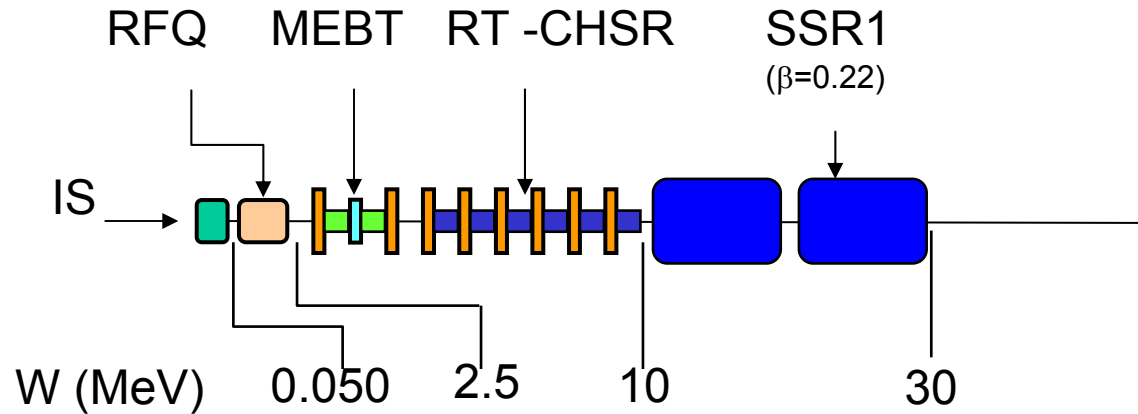


- **End FY07/Beg FY08**

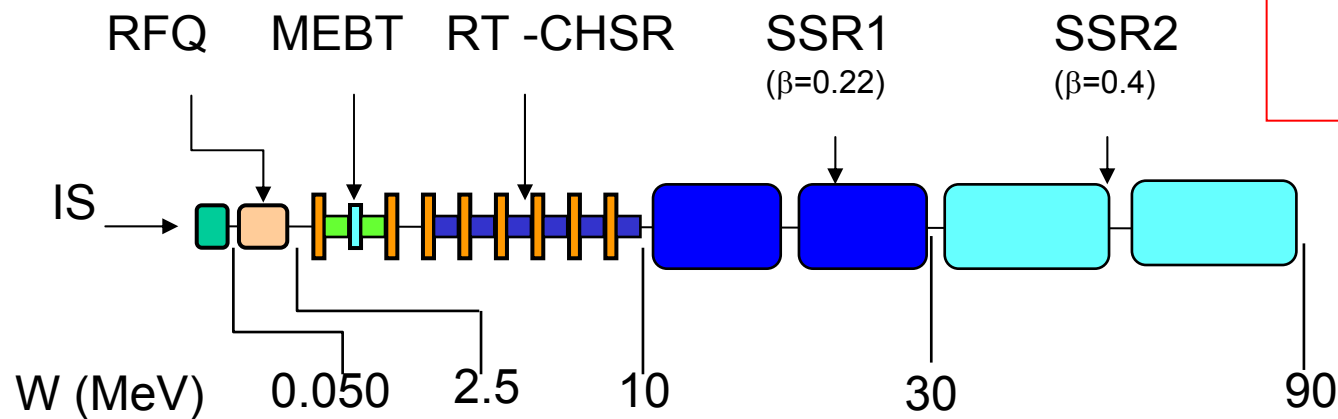
- RT Cavities
- Focusing Solenoids
- Buncher Cavities



# HINS Front End - Stages (2)



- **End FY08/Beg FY09**
  - 2 SSR1 cryostats
  - Chopper & PS
  - Linac Operation



- **End FY09/Beg FY10**
  - 1 SSR2 cryostat
  - Linac Operation

# Organization

- Program Leader
- Program Engineer
- MI/Linac Integration Leader

G. Apollinari

B. Webber

A. Marchionni

3.0 Accelerator Systems B. Webber
3.1 Beam Diagnostics & Instrumentation (old 3.6) M. Wendt
3.2 Modulators, Pulse Transformers & Power Supplies (old 6) D. Wolff / C. Jensen
3.3 Cryogenics (old 5) A. Klebaner / T. Peterson
3.4 Klystrons (old 7) A. Moretti
3.5 RF Distribution (old 8) RF Distr - P. Prieto Phase Shifter - I. Terechkine, D. Wildman RF Controls - B. Chase
3.6 Utilities (old 9) LCW - M. Ball Vacuum - T. Anderson
3.7 Accelerator Controls and Software (old 10) J. Patrick / S. Lackey
3.8 System Engineering Mechanical - T. Nicol / J. Leibfritz Alignment - J. Volk Power - D. Wolff

4.0 Beam Line Components G. Apollinari
4.1 Ion Source through MEBT (old 3.1-3.4) C. Schmidt Ion Source - D. Moehs, H. Piekarz RFQ - G. Romanov Chopper - R. Madrak MEBT - J. Leibfritz
4.2 RT TSR (old 3.5) G. Romanov TSR - G. Romanov Solenoids - J. Tompkins Assembly - T. Page
4.3 Spoke Cryomodules (old 4.1-4.3) G. Apollinari Spoke Cavities - K. Shephard, ANL, G. Apollinari Cryostats - T. Nicol, T. Page
4.4 Beta = 0.81 Cryomodules (old 4.4) N. Solyak Cavities - N. Solyak, (MSU) Cryostat - (ILC)
4.5 Beta = 1 Cryomodules (old 4.5) (T. Nicol / R. Stanek) (ILC)
4.6 MI Transfer Line (old 11, split?) D. Harding

2.0 Conventional Facilities (old 2.0) D. Bogert E. McCluskey
5.0 Machine Design P. Ostromov Linac - P. Ostromov Transfer Line - D. Johnson Main Injector Injection - (BNL?) Main Injector Performance -
6.0 Prototype Facilities B. Webber 6.1 Meson Facility - L. Beverley
3.9 MI Upgrade for PD (off project?) A. Marchionni MI RF Upgrade - D. Wildman / (BNL?) MI Collimation & Shielding MI Neutrino Beamlines and Targets

# Critical Collaborations in Place

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- **ANL**
  - Beam Dynamics
  - Spoke Cavities Processing
- **MSU**
  - $\beta=0.81$  Elliptical Cavities development
- **LBL**
  - Electron Cloud Effects in MI
  - Buncher Cavities
- **BNL – still under negotiation**
  - Injection Studies
  - Stripping Foil Simulation & Engineering
  - Laser Beam Profiler
- **FY06 SOW: ~2.2 M\$**

# HINS R&D Funding

## Resources



Fermilab Accelerator R&D Program							
Dollar amounts in millions, Direct cost only							
	FY2004	FY2005	FY2006	FY2007	FY2008	FY2009	
Run II Upgrades	\$21.0	\$14.4	\$5.6	\$0.0	\$0.0	\$0.0	
Proton Plan	\$0.0	\$3.9	\$6.9	\$6.9	\$1.6	\$1.7	
Near Total	\$21.0	\$18.3	\$12.5	\$6.9	\$1.6	\$1.7	
Linear Collider	\$3.3	\$4.9	\$9.2	\$31.6	\$33.9	\$35.1	
RF Infrastructure & Industrialization	\$0.0	\$6.4	\$12.6	\$5.0	\$10.0	\$30.0	
ILC Bid to Host	\$0.0	\$0.0	\$0.0	\$3.0	\$4.0	\$5.0	
High Intensity Neutrino Source	\$0.9	\$4.4	\$8.3	\$8.5	\$8.8	\$9.1	
Superconducting Magnets (core)	\$2.9	\$3.1	\$2.5	\$2.3	\$2.4	\$2.4	
LARP	\$0.0	\$0.8	\$2.9	\$3.0	\$3.0	\$3.1	
Intermediate Total	\$7.1	\$19.6	\$35.5	\$53.3	\$62.0	\$84.7	
Photoinjector	\$1.1	\$1.6	\$1.0	\$1.0	\$1.0	\$1.5	
Muons	\$1.5	\$1.3	\$1.2	\$1.5	\$1.6	\$2.2	
SciDAC	\$0.1	\$0.1					
Far Total	\$2.7	\$2.9					

- The message:

- Very significant buildup has already started. ILC, HINS, and associated rf infrastructure.

- Total 26.4 M\$ in FY07-FY09

- Labor ~13 M\$
- M&S ~14-15 M\$

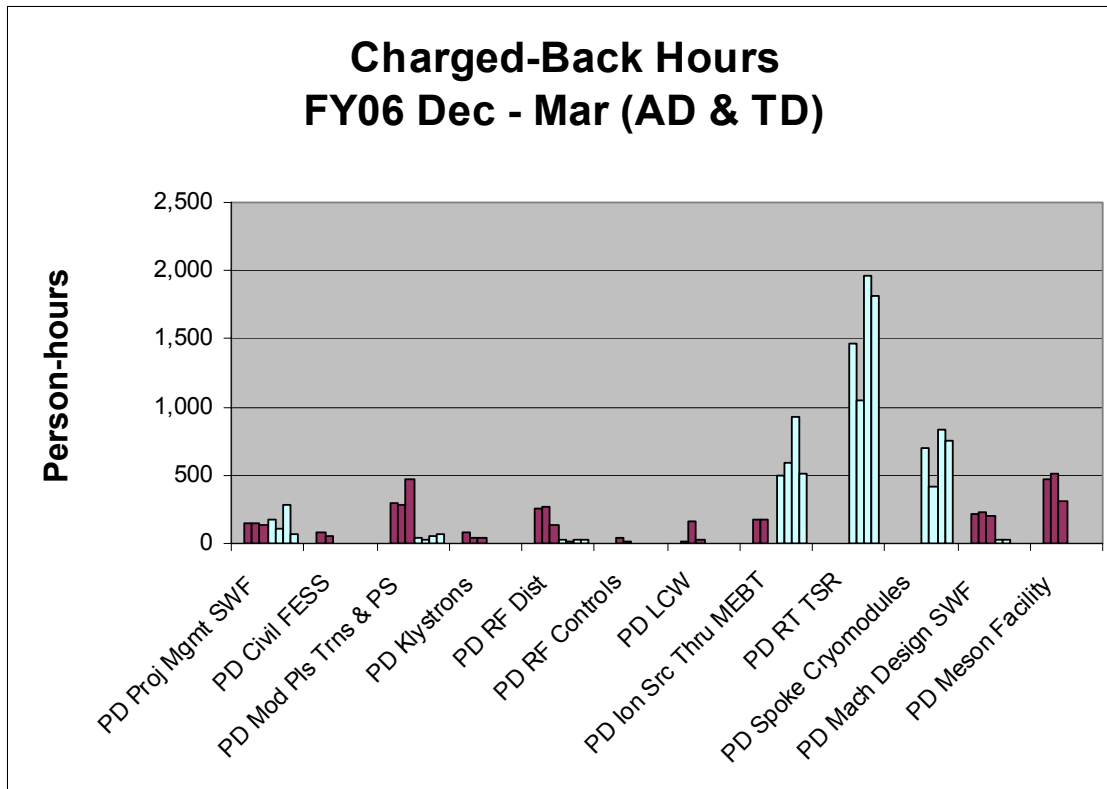
# HINS M&S Procurement Plans in FY07-FY09

<i>Cost</i>	<i>FY05 Director Review Estimate</i>	<i>FY07-FY09</i>
• Ion Source-LEBT	350 k\$	100 k\$
• RFQ	1200 k\$	~ done
• MEBT	220 k\$	~ 400 k\$
• RT	1130 k\$	1130 k\$
• SSR1 Cryo 1-2	3365 k\$	~ 4228 k\$
• SSR2 Cryo 3-4	6468 k\$	~ 5260 k\$
• IQM	3586 k\$	~ 2000 k\$
• Klystron	600 k\$	~done
• Modulator	783 k\$	~done
• (beam diag., LLRF..)	1430 k\$	1430 k\$
• Civil	-	300 k\$
• Total	19,132 k\$	~14,848 k\$

- Hard to keep FY06 level of HINS Collaboration in out years
- Descoping venue: eliminate Cryo #4



# HINS Manpower



- **Average ~4,800 h/month (AD+TD)**
- **~28 charged-FTE or ~33 warm-bodied-FTE (85% ε)**
  - On low end of FY06 plans (22 FTEs in TD + 10-15 FTEs in AD)

# Human Resources

AD	'06	'07	'08
• Beam Physics Design	2 FTE	2 FTE	2 FTE
• Ion Source	1.5 FTE	1.5 FTE	.2
• Klystron & Modulator	3	0.5 FTE	-----
• RF Power Distrib.		1.5 FTE	0.5 FTE
• IQ Modulators		1.5 FTE	1 FTE
• Low Level RF		3	3 FTE
• Beam Instrumentation			3 FTE
• Cryogenics			2 FTE
• Stands & Alignment			7
• Magnet Power			
• Vacuum Systems	1 FTE		
• Controls & Software	FTE		
• Safety Systems	0.5 FTE		
• Installation	1 FTE (0.5 FTE)	1 FTE	
• Integration/Ops.	0.5 FTE	1.5 FTE	
• Management/Support	1 FTE	2 FTE	2 FTE
• Civil/FESS Interface	0.5 FTE	???	???

**FY06 Needs**  
 5 Scientists  
 12.5 Eng (2 Guests)  
 8 Drafters  
 ~14 Techs & Support  
 6 Un-identified (20%)

**FY07 Needs**  
 6 Scientists  
 14 Eng (1 Guest)  
 8 Drafters  
 ~21 Techs & Support

**FY08 Needs**  
 6 Scientists  
 11.5 Eng  
 14 Drafters  
 7+ Techs

**RED – Un-Identified**

# Comments on HR

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- **TD**

- Extremely light on scientists & techs
  - Lack of techs coped with by building prototypes in Industry.
    - End of LHC Quad should/could alleviate issue in TD
  - Lack of scientists more serious. Will the “Build and they will come” approach work ?
    - RFQ & CH RT Cavity being procured
    - For SC components, inevitable competition with ILC

- **AD**

- ~20% of un-identified HR already in FY06



# HINS Human Resources

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- Key technical personnel are working on essential aspects of the Meson Front End Program in both TD and AD.
- Continued technical support is absolutely necessary. Loss of technical support for any of the R&D aspects will prevent the achievement of one or more of the 4 goals in the “0 to 90 MeV Front End” HINS Program
- “Design & Procurement tasks” involve mostly TD personnel, “Installation & Commissioning tasks” involve mostly AD personnel.

# Conclusion

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- **Feasible Plan in place**
- **Major technical progress**
  - Presentations to follow
- **Particular attention to:**
  - Technical & Scientific Manpower resources
  - Funding in out-years